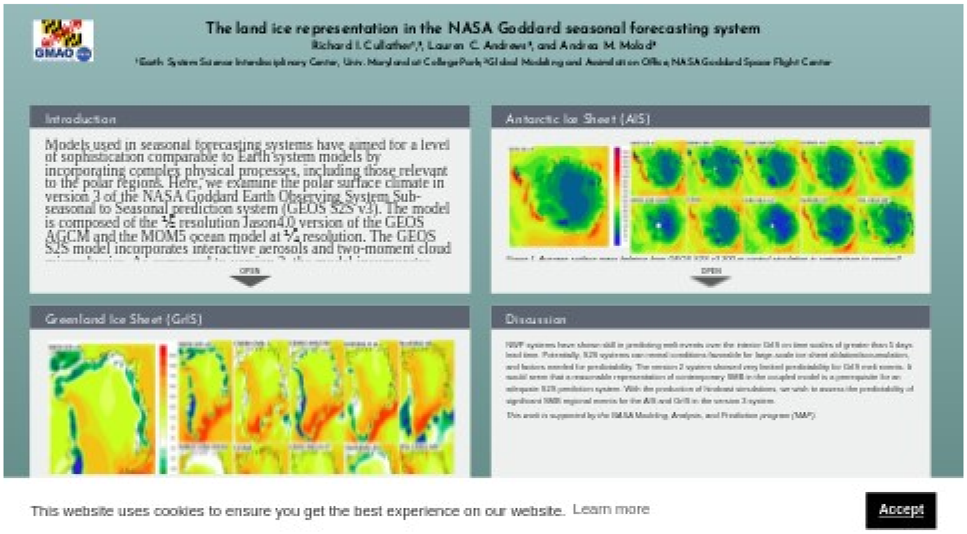
The land ice representation in the NASA Goddard seasonal forecasting system



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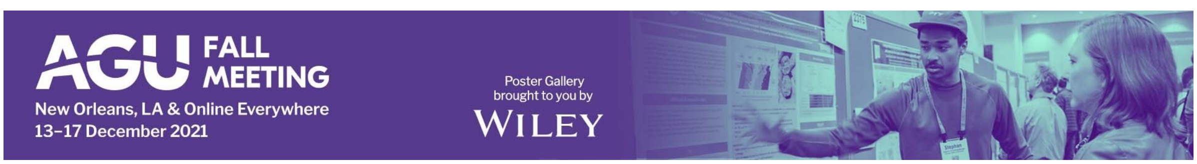

INTRODUCTION

Models used in seasonal forecasting systems have aimed for a level of sophistication comparable to Earth system models by incorporating complex physical processes, including those relevant to the polar regions. Here, we examine the polar surface climate in version 3 of the NASA Goddard Earth Observing System Sub-seasonal to Seasonal prediction system (GEOS S2S v3). The model is composed of the ½° resolution Jason4.0 version of the GEOS AGCM and the MOM5 ocean model at ¼° resolution. The GEOS S2S model incorporates interactive aerosols and two-moment cloud microphysics. As compared to version 2, the model incorporates improved radiative transfer and a redesigned diurnal cycle atmosphere-ocean interface layer. This study aims to understand how the version 3 model compares with version 2, and with contemporary Earth system models.

GREENLAND ICE SHEET (GRIS)

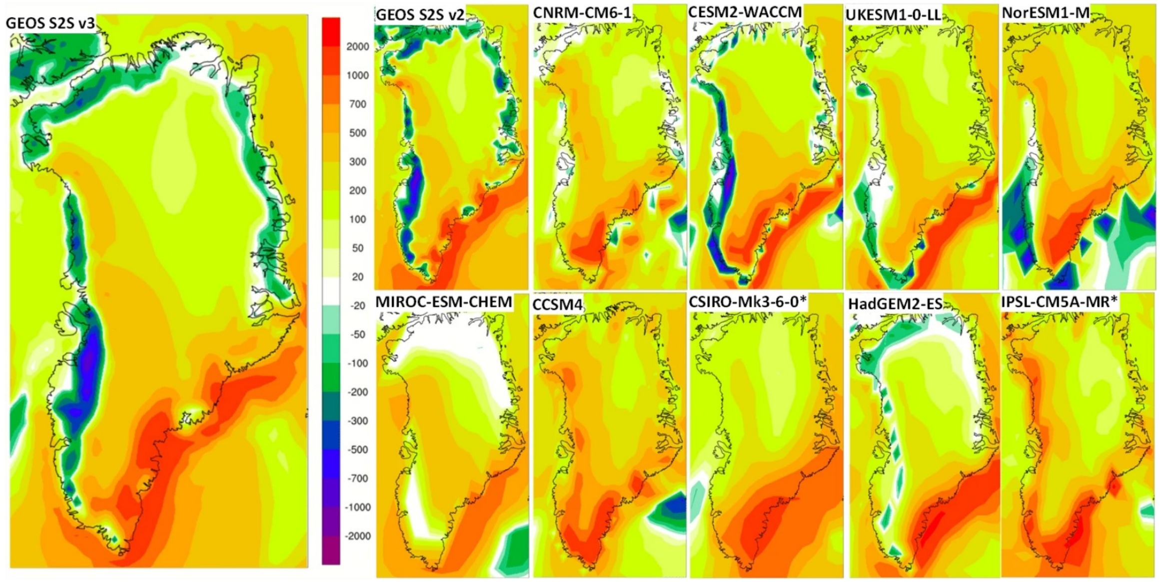

Figure 3. Average SMB from GEOS S2S v3 200-yr control simulation in comparison to version 2 and contemporary ESM models, in mm yr^{-1}.

For the Greenland Ice Sheet (GrIS), the SMB estimate from the control simulation is 408 ± 68 Gt yr^{-1}, which compares with the IMBIE observed estimate 361 ± 40 Gt yr^{-1}. The model captures general features of maximum accumulation in the southeastern GrIS and the ablation zone along the western periphery, although the the largest ablation values of greater than 700 mm yr^{-1} are less than regional model estimates. The narrow western ablation zone is a challenging feature for coarse-resolution ESM models. As compared to version 2, the model shows drier condtions over the NE plateau, but larger accumulation values along the western periphery above the ablation zone.

For the full GrIS, the model represents the contemporary seasonal cycle, which is marked by large mass loss during the summer melt season.

ANTARCTIC ICE SHEET (AIS)

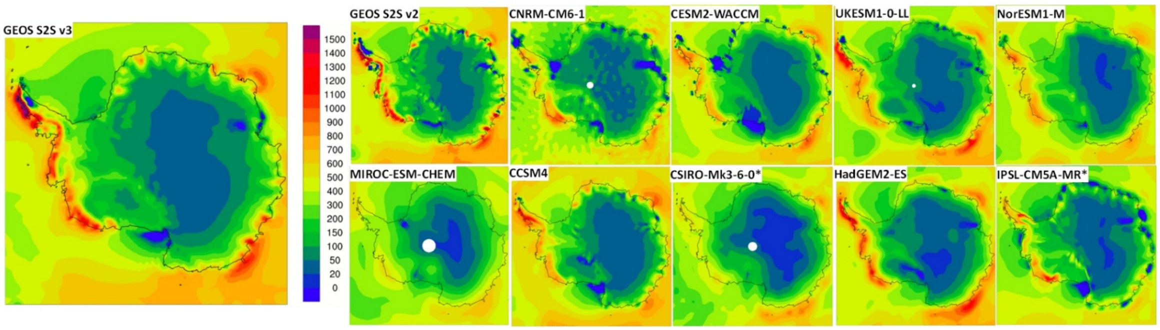

Figure 1. Average surface mass balance from GEOS S2S v3 200-yr control simulation in comparison to version2 and contemporary CMIP5 and CMIP6 Earth system models historical simulations, in mm yr^{-1}

An evaluation of Antarctic Ice Sheet surface mass balance (AIS SMB) from a 200-yr GEOS S2S v3 control simulation shows good agreement with contemporary estimates. The average SMB is 1959 ± 87 Gt yr $^{-1}$, which compares closely with the IMBIE estimate of 1994 Gt yr^{-1}. A comparison of the spatial distribution shows reasonable agreement with CMIP6 CESM2-WACCM and UKESM-0-LL models, which are thought to compare favorably with higher resolution regional estimates. The finite-volume GEOS S2S model compares particularly well in capturing the small accumulation values over the interior plateau. In comparison to version 2, the version 3 model is somewhat drier over the plateau, but shows a better representation of the Lambert Glacier ablation zone. The annual cycle shows the continental minimum in summer months, with largest values in early autumn.

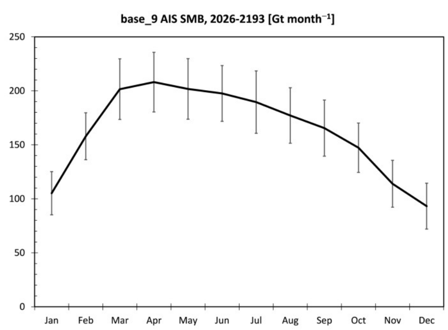

Figure 2. Average annual cycle of GEOS S2S v3 AIS SMB, in Gt month^{-1}.

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DISCUSSION

NWP systems have shown skill in predicting melt events over the interior GrIS on time scales of greater than 5 days lead time. Potentially, S2S systems can reveal conditions favorable for large-scale ice sheet ablation/accumulation, and factors needed for predictability. The version 2 system showed very limited predictability for GrIS melt events. It would seem that a reasonable representation of contemporary SMB in the coupled model is a prerequisite for an adequate S2S prediction system. With the production of hindcast simulations, we wish to assess the predictability of significant SMB regional events for the AIS and GrIS in the version 3 system.

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